DOCUMENT RESUME

ED 037 236 PS 002 702

AUTHOR	Kron, Reuben E.; And Others
TITLE	An Analysis of Behavioral Mechanisms Involved in Control Over Infant Feeding Behavior; The Effect of Interfeeding Interval on Nutritive Sucking in the Newborn.
INSTITUTION	Pennsylvania Univ., Philadelphia.
SPONS AGENCY	National Inst. of Child Health and Human Development, Bethesda, Md.; National Inst. of Mental Health (DHEW), Bethesda, Md.
PUB DATE	[68]
NOTE	30p.
EDRS PRICE	EDRS Price MF-$0.25 HC-$1.60
DESCRIPTORS	Behavior Patterns, *Eating Habits, *Infant Behavior, Motor Reactions, Nutrition
IDENTIFIERS	*Neonates

ABSTRACT

To determine the antecedents of sucking in infants, the behavior of 24 infants from 48- to 60-hours-old was observed in relation to a sucking device. The device measured pressure and rate of sucking and delivered a controlled flow of nutrient. The interfeeding interval was varied among the experimental and control groups. Little sucking behavior was found in the first half hour after routine feeding, but sucking pressure quickly recovered in the first hour and sucking rate gradually reached its highest level by 3 hours after the meal. While a particular child's sucking pressure doesn't ever vary much, his sucking rate, and thus volume of nutrient consumed, is dependent on a variety of environmental factors, including interfeeding interval, obstetric sedation, level of wakefulness, and type of nutrient. Knowledge concerning the factors influencing sucking rate should be applied to the problem of infants who fail to thrive on routine management. (MH)

AN ANALYSIS OF BEHAVIORAL MECHANISMS INVOLVED IN CONTROL OVER INFANT FEEDING BEHAVIOR;

THE EFFECT OF INTERFEEDING INTERVAL ON NUTRITIVE SUCKING IN THE NEWBORN

Reuben E. Kron, M.D.
Violet S. Kron, M.D.
Marianne D. Phoenix, R.N.

Department of Psychiatry, and Department of Pediatrics,
University of Pennsylvania School of Medicine

Address: (R.E.K.) Hospital of the University of Pennsylvania
Room 202, Piersol Building, 3400 Spruce Street,
Philadelphia, Pa. 19104

LEAD SUMMARY

Adequate nutrition is essential for normal infant growth and development; and unexplained failure to thrive creates the most difficult management problems for the pediatrician. However, there is a paucity of factual information about the specific mechanisms involved in the control over the suckling infant's consumatory behavior, which might assist the clinician in regulating the feeding responses of his small patients. The authors have developed a method for measuring nutritive sucking and are investigating constitutional and environmental factors which control the infants' feeding activities. This study reports the effect upon nutrient consumption of experimentally varying the interfeeding interval; discusses the behavioral mechanisms involved in mediating organismic and environmental control over food intake; and suggests a rationale for the behavioral management of nutritional disturbances of infancy due to inadequate dietary intake.

Malnutrition of infancy has become much less frequent in our society because of improved nutritional and hygienic practices; however, there remains a core of unexplained disorders of early feeding behavior that have not responded to modern pediatric management (1). Scientific knowledge about early feeding behavior has not kept pace with the increased comprehension of nutritional and metabolic physiology in the infant. The causes of rare inborn errors of metabolism are more readily identified than the etiology of common colic (1). Observations in the newborn nursery reveal substantial differences among infants in feeding behavior. It is generally assumed that variations in the vigor of feeding activities reflect the vitality of the newborn and may influence subsequent growth and development (2). However, the specific factors that govern the level of infant feeding behavior have not been extensively studied. The average infant appears to thrive under a variety of feeding schedules, formulas, and types of maternal handling. As a result many of our modern infant feeding practices are a distillate of maternal intuition and clinical expedience (3). Although generally successful, these practices are applied without awareness of the specific determinants of the infant's feeding behavior. The need to understand the factors which control feeding becomes evident when the pediatrician encounters infants who fail to thrive under routine management.

Students of behavior have long stressed the importance of early sucking activities to survival and behavioral development of the infant. Early investigators, such as Preyer (4), tended to be most impressed by the inborn and apparently immutable characteristics of infant feeding activities; while contemporary researchers, like Lipsitt (5), have been primarily concerned with uncovering the functional relationships between environmental stimuli and the sucking response. Recent studies by the authors have indicated that the rhythmicity of sucking behavior is governed by constitutional factors (6, 7), and that inborn differences account for some of the individual variability in feeding behavior observed during the newborn period. The authors have also been studying the effects of organismic and environmental influences upon newborn feeding activities in order to identify

the modifiable aspects of the infants' consumatory responses. Such information may lead to a more complete understanding of the process of behavioral acquisition and provide a scientific basis for therapeutic modification of feeding activities.

The infant feeds by generating pressure pulses (sucks) which have an amplitude (pressure) and frequency of occurrence (rate). In regulating nutrient intake the infant may vary rate and pressure independent of one another. Analysis of the differential effects of inborn and environmental factors upon sucking rate and pressure may disclose the behavioral mechanisms that mediate control over food intake. The authors have devised a technique for recording and analyzing nutritive sucking (8), and the following factors have been found to significantly effect feeding behavior: chronological age (8); inborn differences in sucking behavior (7); prior sucking experience (8, 9); type of nutrient provided (5); obstetric analgesia (10); the infant's state of arousal (11); and the interfeeding interval. This paper reports the effects of interfeeding interval upon newborn sucking; analyzes the behavioral mechanisms which mediate control over the infant's nutrient consumption; and suggests a rationale for behavioral modification of disturbed infant feeding.

METHODS

The instrument for measuring sucking behavior has been previously described in detail (8); it is designed so that the volume of nutrient delivered to the infant is directly related to both the rate and the pressure of sucking. The apparatus (Figure 1) provides precise control over the flow rate of the nutrient while recording sucking pressures from within the mouth of the infant. The oscillographic recordings (Figure 2) from the sucking instrument permit the measurement of the peak negative pressure of each suck and the number of sucks per unit of time. The rate is calculated from the average number of sucks per minute throughout the test feeding. The pressure is scored as the average peak millimeters of Hg. per suck for each minute of the test feeding. The volume consumed during sucking is calculated from the drop in

fluid level in the nutrient reservoir and is scored as the average number of milliliters of nutrient consumed each minute.

INSERT FIGURES 1 AND 2

The subjects consisted of 6 groups of 4 infants each, randomly selected from the ward nursery of a large municipal hospital. Maternal permission was obtained for all experimental procedures. Each subject was given a thorough pediatric examination and the obstetrical information was evaluated to exclude infants with clinically detectable abnormalities. All infants were bottle fed. The subjects were 48 – 60 hours of age at the time of the study. This age was chosen to permit recovery from perinatal sources of variability; prior studies (6, 7, 8) having indicated no significant day-by-day changes in sucking behavior after 48 hours of age. The means and standard errors for population parameters of the mothers and infants can be seen in Table 1. The overall means for the 24 mothers and 24 infants did not differ significantly from the population parameters in previous studies (6, 7, 8, 10).

INSERT TABLE 1

The following standard operating procedure was used. A 9-minute control feeding was administered 4 hours ± 30 minutes (12) after the previous 6:00 A.M. routine nursery feeding and immediately prior to a 10 to 20 minute bottle feeding of 2 to 3 ounces of milk formula which supplanted the routine 10:00 A.M. nursery feeding. This amount of formula was chosen after a survey of 50 consecutive admissions to the newborn nursery indicated that the mean and standard error for consumption during routine nursery bottle feedings was 2.5 ± 0.1 ounces at 48-60 hours of age. A 9-minute experimental feeding was then administered to each group of four infants, respectively, at 1/2 hour, 1 hour, 2 hours, 3 hours, 4 hours, or 5 hours after termination of the bottle feeding. The control,

experimental, and 10 A.M. bottle feedings were administered by the research nurse in a small laboratory adjoining the newborn nursery. During the control and experimental feedings, the infant was kept in its nursery wrappings, and remained on its back in a bassinet. The research nurse made no attempt to stimulate the infants to suck, other than to insert and maintain the nipple in the mouth during the test feedings (Figure 3). The state of arousal of each infant was continually monitored by observing the magnitude of body movements and vocalizations, and scored for every minute of the control and experimental feedings. The arousal data was recorded on a 4 level behavioral rating scale: 1. sleep (eyes closed, inactive, and quiet); 2. minimal activity (eyes open, alert, and quiet); 3. moderate activity (restless, whimpering); 4. high activity (much movement, crying).

INSERT FIGURE 3

The milk solution used during control, experimental, and bottle feedings was formulated from 100 gm. of Alacta* and 100 gm. of Dextri-Maltose #1* in 2,000 ml. of H_2O autoclaved for 25 min. at 100° C. and fed to the infants at room temperature (27° C.). Environmental conditions such as room temperature, noise, and illumination were kept constant.

The data for sucking rates, pressures, and amounts consumed were computed for each minute of the 9 minute control and experimental feedings at each interfeeding interval. The 9 minute feeding was chosen because prior studies (6, 7, 8) indicate that the sucking measures are consistent from minute-to-minute during this period, while longer feedings result in decreased sucking, probably in response to stomach filling and fatigue. The minute-by-minute data were then compared within a mixed model analysis of variance for repeated measures, with minutes and trials fixed (13). First, the significance of the

---

*Mead Johnson Laboratories, Evansville, Ind.

difference between control and experimental trial means was evaluated at each interfeeding interval. Next comparisons were performed between trial means at successive interfeeding intervals to test the significance of changes in each sucking variable as a function of time since the last feeding; also, to uncover differences in temporal effects upon each of the sucking variables. Then a further analysis was performed to study the behavioral mechanisms involved in regulating nutrient intake: the relative contribution of changes in sucking rate and pressure to variance in the amount consumed was investigated using parametric correlational techniques (14).

RESULTS

INSERT TABLES 2 and 3

The sucking data were summarized by averaging the minute scores of each infant for each sucking variable during control and experimental feedings and then calculating the trial means and standard errors for each group of 4 infants. These data are found in Tables 2 and 3, and illustrated in Figures 4, 5, and 6 as percentage of control values. The rate and pressure of sucking, and thus the amount consumed 1/2 hour after the routine bottle feeding, were negligible. Sucking pressure (Figure 4) recovered most rapidly (within an hour); however, sucking rate (Figure 5) did not attain control levels until 3 hours after the routine feeding. Increases in the amount consumed (Figure 6) paralleled sucking rate in attaining control levels at 3 hours. Therefore, temporal control over nutrient consumption is mediated by changes in both the rate and pressure of sucking; however, each sucking variable has a distinct time course. While sucking rate increases gradually over time, changes in pressure are mainly on an "all or none" basis. From Table 2 it can be seen that 3 of the 4 infants in the 1/2 Hour Group did not suck at all during the experimental feeding (pressure = 0), yet in the 1 Hour Group and thereafter each infant tended to generate its characteristic

range of sucking pressures during the experimental feeding. At 3, 4, and 5 hours, there was no discernible difference between the control and experimental feedings in any sucking variable (12).

INSERT FIGURES 4, 5, AND 6

Significance of Between Trials Differences

The minute-by-minute data for each matched set of control and experimental feedings ($n = 4$) were compared within the analysis of variance for repeated measures. There were significant differences between control and experimental trial means at 1/2 hour for sucking rate ($F = 16.46$, $P < .01$, with df 1/6) and amount consumed ($F = 12.07$, $P < .05$): and differences approaching significance for sucking pressure at 1/2 hour, and for sucking rate at 2 hours (Table 3). Because of the small number of infants in each group, there were no other significant differences found between the control and experimental sucking measures. In order to increase the power of the statistical analysis, the data from the six interfeeding interval groups were combined ($n = 24$) and multiple comparisons were performed within the analysis of variance. Consecutive pairs of the control, and consecutive pairs of the experimental trial means were tested for significant differences (i.e. $\bar{X}_{1/2\ hr.}$ and $\bar{X}_{1\ hr.}$; $\bar{X}_{1\ hr.}$ and $\bar{X}_{2\ hr.}$; $\bar{X}_{2\ hr.}$ and $\bar{X}_{3\ hr.}$; $\bar{X}_{3\ hr.}$ and $\bar{X}_{4\ hr.}$; $\bar{X}_{4\ hr.}$ and $\bar{X}_{5\ hr.}$). No differences were found between any of the successive control feedings in measures of sucking behavior. However, there were significant differences between consecutive experimental feedings:

a. For pressure, the mean for the 1 hour interfeeding interval group was significantly greater than that of the 1/2 hour group ($F = 50.55$, $P < .01$, with df 1/16). None of the other group means differed significantly among themselves. Figure 4 indicates that asymptotic levels of sucking pressure were achieved in 1 hour.

b. For rate, the 1 hour trial mean was significantly higher than the 1/2 hour mean ($F = 41.47$, $P < .01$); the 2 hour trial mean was greater than the 1 hour mean ($F = 5.24$, $P < .05$); and the 3 hour mean larger than the 2 hour ($F = 5.81$, $P < .05$). None of the remaining group means differed significantly among themselves. Figure 5 indicates that asymptotic levels of sucking rate were reached at 3 hours.

c. For amount consumed, the trial mean for the 1/2 hour interfeeding interval was significantly less than the 1 hour trial mean ($F = 34.46$, $P < .01$). The other trial means did not differ significantly. Figure 6 shows that asymptotic levels were not achieved until 3 hours. The statistical finding indicates that the principle increases in the amount consumed are dependent upon the significant changes in both pressure and rate during the first hour after a meal as both increase from zero; however, the further significant increases in sucking rate during the next 2 hours are reflected in additional (but less substantial) increases in nutrient intake. This means that the infant must begin to emit sucks (pressure pulses) before nutrient consumption can commence; however, once the infant begins to suck, the amount of formula ingested is dependent upon the rate at which the sucks are being emitted.

In order to further clarify the behavioral mechanisms involved in regulating nutrient intake, an analysis was carried out to estimate the relative importance of variations in sucking rate and pressure in determining the amount consumed within and between the control and experimental feedings.

Partitioning of the Within Trials Variance for Consumption

INSERT TABLE 4

An analysis was performed to estimate the relative importance of within trials differences between individual infants in sucking rates and sucking pressures

to differences in the amounts of nutrient consumed. First, the interrelationships among the trial means for the 3 sucking variables were computed, and then the multiple correlation coefficients of rate and pressure upon amount consumed were calculated. In Table 4 it will be seen that $R_{cons.-rate \times press.} = .817$ for the control, and $R_{cons.-rate \times press.} = .916$ for the experimental feedings. Since a causal relation exists between the independent variables (rate, pressure) and the dependent variable (amount consumed), the square of the multiple correlation coefficent (R^2) gives the portion of the variance in the amount consumed that is explained by knowledge of both rate and pressure. Rate and pressure together explain 66.9% of the variance in consumption during control, and 84.0% of the variance in amount consumed during experimental feedings. The remaining unexplained variance is related to differences in the shape of the envelope (time-pressure curve) of each suck, and especially to individual differences between infants in the time duration (Figure 7). In a recent study (15) the authors found that differences between infants in the time duration of the suck account for most of the variance in amount consumed, not already explained by rate and pressure.

INSERT FIGURE 7

Further analysis was performed to estimate the relative contribution of rate and pressure to the explained variance in amount consumed. Rate and pressure are measured in different units and were, therefore, converted into beta coefficients (β) as standard scores. The squares of the respective beta coefficients (β^2) provide the relative weighting of each independent variable in partitioning the variance of the dependent variable. Within both the experimental and control feedings, the differences between infants in sucking pressures were approximately four times more important than differences in rate in determining the volume

consumed by each infant during the feeding (Table 4). Thus pressure, rather than rate, tended to be a better predictor of the amount consumed by an infant during a given feeding. Table 2 demonstrates this phenomenon. For example, during the control feeding for the 1 Hour Group: Infant N had one of the highest sucking rates (64.7/min.) and a relatively low average peak pressure (-34.3 mm. Hg.) yet the amount consumed by N (1.35 ml./min.) was less than average for all controls; Infant H in the same group had one of the highest pressures (-102.7 mm. Hg.) and a relatively low rate (36.7/min.), but the amount consumed by H (2.13 ml./min.) was much higher than average for all controls.

Analysis of the Between Trials Variance

Estimates of <u>between</u> trials variance measure the differential effects of the experimental factor (interfeeding interval) upon the behavioral variables (rate and pressure) that regulate nutrient consumption. Further analysis was carried out to test the consistency of the sucking measures between the control and experimental feedings. The correlation coefficients for rates, pressure, and amounts consumed were calculated. The squares of the respective correlation coefficients estimate the proportion of the variance in the sucking measures during the experimental feeding, that is predicted from knowledge of the control feeding. It was found that for pressure $R = .750$* ($R^2 = .563$); for rate $R = .369$ ($R^2 = .136$); and for consumption $R = .461$ ($R^2 = .213$). There is a significant consistency for individual infant sucking pressures across the control and experimental feedings, indicating that if the infant sucks at all, he tends to emit his characteristic range of pressures (Table 2). However, sucking rates are highly influenced by gradations in the interfeeding interval.

If the correlations between the control and experimental feedings are limited to the trials when the sucking measures have attained asymptotic levels, the correlation for rate (including only the 3, 4, and 5 hour interfeeding intervals)

---

*for df = 24, $R > .496$ is significantly greater than 0 at the .005 level of confidence.

improves to significant levels (R= .659*), while pressure (eliminating the 1/2 hour interval) remains unchanged (R= .745*). Pressure correlates well across different environmental conditions because it is an inherent behavioral characteristic of the infant; while rate correlates well across similar conditions because it is dependent primarily upon the infant's state at the time of feeding (16).

The meaning of these statistical findings is that under a given set of circumstances (within trials) the variations between infants in nutrient intake are primarily explained by consistent individual differences in pressure of sucking; however, as the situation changes (between trials), primary control over nutrient consumption is afforded by factors that effect the rate at which the sucking responses are emitted.

Recordings of Arousal

The minute-by-minute ratings of arousal indicate that the measures of nutritive sucking reflect and amplify clinically observable changes in general motor activity at each interfeeding interval. As can be seen from Table 2, there was little if any sucking 1/2 hour after a full bottle feeding. The surfeited infants tended to be asleep or in states of minimal activity (level 1 or 2) prior to, and throughout the experimental feeding. Nutritive sucking in response to the nipple was absent in all but infant P, and in that baby, the infrequent sucks tended to be irregular in occurrence and of low pressure. At 1 and 2 hours, the infants exhibited a wider range of activation and sucking was vigorous, but still irregular in some infants. Immediately before the 3, 4, and 5 hour feedings (and all the control feedings) the infants ranged from states of sleep to crying (levels 1 to 4); however, in response to the nipple they respectively awoke or quieted, entering into a state of minimal motor activity (level 2), which was maintained throughout the feeding. The infants seemed to suppress general body movements and vocalizations, and to concentrate their efforts upon sucking with great vigor and rhythmicity (Figure 3).

DISCUSSION

Precise knowledge about the behavioral mechanisms involved in control over nutrient intake may facilitate the treatment of feeding problems during the suckling period. Analysis of our experimental data indicates that sucking rates and pressures are regulated by different behavioral mechanisms. The amplitude of each suck (pressure) appears to be a constitutional element of the feeding response, and as such may be considered the individual infant's inborn "response unit." Infants may be characterized as "high," "average," or "low" in sucking pressures as early as the first day of life (7), and consistent individual differences in sucking pressures are responsible for most of the variation between infants in the amount consumed under a given set of environmental circumstances (within trials). However, as conditions change (between trials) the infants tend to alter the volume of nutrient consumed by varying the rate of sucking (i.e. the frequency at which they emit response units). Therefore, organismic and environmental factors which influence the rate of sucking will exert regulatory control over the infant's intake of nutrient.

Organismic Factors

Within the cognitive frame of reference, hunger is the learned ability to discriminate physiological states of nutritional need; and serves as the appropriate cue for food seeking and consumatory behaviors. The concept of hunger is not applicable during the immediate postnatal period. The newborn's discriminative and response capabilities are insufficiently developed (9, 11), and the infant lacks the prior feeding experience necessary to learn the signal value of its physiological stimuli. Therefore, earliest control over the rate of sucking is mediated by non-specific behavioral mechanisms. Changes in the level of organismic stimulation, as a function of the time since the last feeding, may explain the increases in sucking rate found in our study. Probable sources are visceral sensations, such as gastric contractions and distention, in response to stomach filling and emptying. Preloading the infant's stomach with milk inhibits the sucking response of the

newborn (17), and radiography of the infant's stomach indicates gradual emptying during the two hours after a milk formula feeding (18). These findings suggest that sensations from the empty stomach determine the level of sucking behavior. The arousing organismic stimuli increase the level of general motor activity, and when the infant is fed, the increased motor excitability is reflected in higher rates of sucking; stomach filling results in decreased arousal and a concomitant decrease in activity (19). The sucking responses of the normal newborn wax and wane with changes in arousal (20). The fortuitous association between inner sensations, sucking, and stomach filling become the basis for the learned tendency to eat in response to nutritional need. Vicissitudes in the learning process may result in an abnormal sense of hunger. Clinical observations indicate that infants vary in response to organismic stimuli. Hypo- or hyper-reactive infants may not acquire normal feeding habits unless the conditions for learning are optimized. Therapeutic manipulation of environmental factors may facilitate the acquisition of an appropriate sense of hunger.

Environmental Factors

Environmental stimulation affects sucking rate by directly altering the state of arousal. The nature of the effect upon sucking is the result of an interplay between stimulus characteristics and the infant's physiological readiness to respond at the time of stimulation. For example, the palatability of the nutrient has little effect upon sucking by satiated infants; however, in unfed infants the type of nutrient significantly affects the sucking rate (6). The authors reported that newborns suck at higher rates and consume more milk formula than 5% corn syrup solution. Therefore, in infants with inadequate intake, more palatable formulas may increase the sucking rate. The authors also found that obstetric sedation depresses the sucking response (10). Infants born to mothers who received a single 200 mg. dose of secobarbitol sodium* during the labor sucked at lower rates and consumed less nutrient than infants born to mothers who received no barbiturates. The

*Eli Lilly Co., Indianapolis, Ind.

significant drug effects persisted throughout the in-hospital period. Since routine doses of obstetric sedation attenuate the infants spontaneous feeding responses for prolonged periods, these drugs may be responsible for some unexplained disturbances in early feeding behavior.

Feeding responsivity is dependent upon the infant's state of arousal and pacification. This fact is recognized by experienced nursery personnel who generally provide tactile, kinesthetic, and auditory stimuli to initiate and maintain the infant's feeding activities. However, among infants one finds some who respond idiosyncratically to environmental stimulation. For example, in our experimental studies of arousal (11), we found that periodic interruption of nutrient flow tended to generate very high average rates of sucking and high levels of nutrient consumption in groups of newborns. However, the individual infants within the group varied greatly in their response - some would consistently reject the nipple, and begin crying when thus stimulated! Awareness of the newborn's response characteristics may facilitate pediatric and maternal handling to enhance the infant's behavioral development. Our experimental data and clinical observations indicate that certain optimal conditions are required for organismic and environmental factors to collaborate in the development of a normal sense of hunger. Variations in physiological state are manifested in changes in general activity levels, for example, the sleep and waking cycles of the newborn; environmental factors, such as the patterns of maternal handling, impinge upon and influence these inherent biological rhythms. The perceptive mother detects the infant's cyclic changes in state, and adjusts her caretaking behaviors accordingly. The mother's synchronization of feeding with the newborn's physiological state of nutritional need lays the foundation for the infant's identification of the signal value of his internal sensations. Later with the accretion of experience and maturation of discriminative and response capabilities, the coordination between feeding behavior and changes in internal stimuli becomes the basis for associative learning and results in the infant's ability to perceive hunger (21). Problems in

infant feeding behavior may result from the dissonance between the infant's physiological needs and the maternal response. Inability of the infant to learn the relationship between its consumatory activities and the relief of arousing organismic stimuli may result in states of chronic hyper-irritability and inadequate food intake. Development of the normal hunger-satiety cycle may be thwarted and lead to feeding disturbances in later life.

SUMMARY

The understanding of normal feeding activities and the rational management of disturbed feeding behavior in the suckling infant are predicated upon the discovery of, and control over, the specific organismic and environmental factors which regulate nutritive sucking. Definition of the functional relationship between specific regulatory factors and the individual infant's consumatory response will facilitate the design of effective methods for the therapeutic modification of abnormal suckling behavior.

This report analyzes the behavioral mechanisms involved in mediating organismic and environmental control over food intake, and, in particular, the differential effects upon sucking rates, sucking pressures, and amounts consumed caused by experimentally varying the time interval between feedings. It was found that the rate and pressure of sucking and the amount consumed one-half hour after a routine feeding were negligible; sucking pressure quickly recovered within the first hour while sucking rate gradually attained asymptotic levels by 3 hours after the meal; the volume of nutrient consumed paralleled sucking rate in recovery. Sucking pressure appears to be an inborn trait. If the infant sucks at all, it tends to emit its characteristic range of peak pressures. The rate of sucking is highly responsive to a variety of environmental factors. Interfeeding interval, obstetric sedation, level of wakefulness, and type of nutrient are significant determinants of the infant's sucking rate.

This report also considers the importance of identifying individual differences in responsivity when prescribing for infants who fail to thrive on routine management and describes an approach to the behavioral management of nutritional disturbances in infancy.

REFERENCES

1. Pediatrics, 14th Edition. Barnett, H. L. (Ed.) et al. Meredith, New York, 1968.
2. Hytten, F. E. Observations on the vitality of the newborn. Arch. Dis. Child. 26:477, 1951.
3. Aldrich, C. A. and Aldrich, M. M. Feeding Our Old Fashioned Children. Macmillan, New York, 1941.
4. Preyer, W. The Mind of the Child: Part I - The Senses and the Will. (Trans. by H. W. Brown). Appleton, New York, 1888.
5. Lipsitt, L. P., Kaye, H., and Bosack, T. N. Enhancement of neonatal sucking through reinforcement. J. Exp. Child Psych. 4:163, 1966.
6. Kron, R. E., Stein, M., Goddard, K. E., and Phoenix, M. D. Effect of nutrient upon the sucking behavior of newborn infants. Psychosom. Med. 29:24, 1967.
7. Kron, R. E., Ipsen, J., and Goddard, K. E. Consistent individual differences in the nutritive sucking behavior of the human newborn. Psychosom. Med. 30:151, 1968.
8. Kron, R. E., Stein, M., and Goddard, K. E. A method of measuring sucking behavior of newborn infants. Psychosom. Med. 25:181, 1963.
9. Kron, R. E. Instrumental conditioning of nutritive sucking behavior in the newborn. In Recent Advances in Biological Psychiatry: Vol. IX. Wortis, J. (Ed.) Plenum Press, New York, 1967. pp. 295-300.
10. Kron, R. E., Stein, M., and Goddard, K. E. Newborn sucking behavior affected by obstetric sedation. Pediat. 37:1012, 1966.
11. Kron, R. E. The effect of arousal and of learning upon sucking behavior in the newborn. In Recent Advances in Biological Psychiatry. Vol. X. Wortis, J. (Ed.) Plenum Press, New York, 1968. pp. 302-313.
12. Our previously reported studies were performed 4 hours ± 30 minutes after the prior routine nursery feeding, and the findings of the current study indicate that this range of interfeeding intervals does not attenuate the reliability of repeated measures of sucking behavior.

13. Edwards, A. L. Experimental Design in Psychological Research. (Revised Edition) Holt, Rinehart and Winston, New York, 1960.

14. McNemar, Q. Psychological Statistics. 3rd Edition. J. Wiley, New York, 1962.

15. Kron, R. E. Fluid mechanics of nutritive sucking behavior: The suckling infants' oral apparatus analyzed as a hydraulic pump. Paper presented at Annual Meeting of the Society for Psychophysiological Research, Washington, D. C., 1968.

16. Escalona, S. K. The study of individual differences and the problem of state. J. Child Psych. 1:11, 1962.

17. Satinoff, E. and Stanley, W. C. Effect of stomach loading on sucking behavior in neonatal puppies. J. Compar. and Physiol. Psychol., 56:66, 1963.

18. Smith, C. A. The Physiology of the Newborn Infant. 3rd Edition. Thomas, Springfield, Ill., 1959.

19. Aserinsky, E., and Kleitman, N. A motility cycle in sleeping infants as manifested by ocular and gross bodily activity. J. Applied Physiol. 8:11, 1955.

20. Bridger, W. H. The effects of hunger and arousal on the sucking activity of newborn infants. Paper presented at Annual Meeting of Society for Research in Child Development, State College, Pa., 1961.

21. Hebb, D. O. The Organization of Behavior. J. Wiley, New York, 1949.

22. Apgar, V. A proposal for a new method of evaluation of the newborn infant. Curr. Res. Anesth. Analg. 32:260, 1953.